SPECIFICATION

ECONOMICAL AND ENVIRONMENTALLY SUSTAINABLE METHOD OF RECYCLING WASTEPAPER

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The field of the present invention is processes for recycling wastepaper.

2. Background

[0002] Consumers frequently place a premium on the softness of certain paper products such as paper towels and tissues. The softest of such paper products, however, are typically manufactured with significant quantities of virgin fibers, as opposed to recycled fibers, because virgin fibers provide the most economical source of raw materials for high-performance paper products. Even when recycled fibers are used in towel and tissue products, virgin fibers are often added to achieve the level of softness desired by the consumer. Unfortunately, obtaining a soft towel or tissue product from recycled fiber is not necessarily a straightforward process.

[0003] Recycling fibers for use in new paper products creates at least two potential problems for manufacturers of high-performance products, the first being economical in nature and the second being environmental. The economic problem stems from the difficulty in processing recycled fibers and manufacturing the recycled fibers into a desirable consumer product, e.g., soft towels and tissues. The environmental problem stems from recycling process as a whole and the contaminants present in the wastepaper stream.

[0004] The problem with achieving a soft paper product from recycled fiber stems from fines, small fiber particles, found in the wastepaper stream. On one hand, if

significant amounts of fines remain in the wastepaper stream, they increase internal fiber bonding thereby interfere with the production of a soft paper product. On the other hand, if the fines are substantially removed and discarded, then the recycling process becomes uneconomical. Compounding the economic problem is the environmentally harmful contaminants present in the wastepaper stream, the removal of which only adds to the expense of recycling. Also, the process of recycling wastepaper consumes large amounts of fossil fuels.

[0005] The typical composition of coated publication grade wastepaper is 50% long fiber, 30% filler (such as kaolin clay, calcium carbonate, and other inorganic material), 15% fines, and 5% other (such as ink, binders, and starch). The process of separating the long fiber from the other components of the wastepaper stream through fractionation at the washing stage is well known to those skilled in the art.

[0006] Of the components in the wastepaper stream, the long fiber is the most desirable and useful for inclusion in new paper products. As to the other material in the wastepaper stream, unless it is productively used in some manner, it is placed in a landfill. Disposing 50% or more of the wastepaper stream in a landfill places tremendous economic and environmental burdens on the recycling process. Methods which at least partially alleviate these burdens have been developed for processing the other components of the wastepaper stream. Examples of such methods may be found in U.S. Patent Nos. 5,846,378, 6,063,237, and 6,511,579. These methods enable the fines and fillers in the wastepaper stream to be used in new paper products, thus increasing the overall recovery of the wastepaper stream to about 70%. However, although these methods recover and use a greater portion of the wastepaper stream, thereby increasing the economic efficiency of recycling, they do little to address some of the environmental concerns associated with recycling wastepaper, and it is not possible to produce high-performance paper products from the resulting fiber.

[0007] One such concern surrounds the environmentally harmful chemicals present in the wastepaper stream, including PCB, and other volatile organic chemicals. None of the aforementioned patents take any steps to actively remove such environmentally harmful chemicals from the wastepaper stream. At best, the presence of these chemicals is addressed only peripherally.

[0008] For example, in the recycling process described in '378 and '237 patents, the long fiber in the wastepaper stream is first separated from the sludge, i.e., all the other material in the wastepaper stream. Following separation, the sludge is heat treated to render at least part of the sludge useable, along with the long fiber, in new towel and tissue products. One byproduct of this heat treatment process is the production of volatile organic gases. These gases are contained and destroyed in a separate heat treatment stage to avoid damaging useable components in the sludge. Those environmentally harmful chemicals that are not gaseously emitted during the first heat treatment stage, however, remain in the wastepaper stream and become part of the new paper products produced therefrom.

SUMMARY OF THE INVENTION

[0009] The present invention is directed towards a method of recycling wastepaper. A wastepaper stream is processed to separate out the long fiber content. The remaining portion of the wastepaper stream (the "sludge") is combusted to create ash, and the ash undergoes a process to reduce the overall size of the ash particles. Once reduced to the desired size, the ash is metered back into the long fiber content, and the combination may be used in the production of new paper products.

[0010] In a first separate aspect of the present invention, the wastepaper stream processing includes fractionating the stream into a long fiber stream and a sludge stream. The sludge stream includes the fines, filler (clay, calcium carbonate, etc.), and other matter such as binders, ink, and solubles. The sludge stream is then combusted

at temperatures above 1100° F, and preferably at vapor temperatures above 1700° F, to form the ash.

[0011] In a second separate aspect of the present invention, before the sludge stream is combusted, it is dried to remove excess water. The drying process enables autogenous combustion of the matter in the sludge stream once it is inserted into a combustion chamber. The drying process may include drying the sludge stream by pressing it in a conventional manner, heating it with steam, or any other appropriate process.

[0012] In a third separate aspect of the present invention, parameters of the combustion process are controlled to help prevent the formation of undesirable byproducts. For example, selective catalytic reduction processes and techniques may be employed to reduce the formation of NO_X and SO_X. Such processes and techniques include, among other things, providing a low oxygen environment for combustion, injecting aqueous ammonia into the combustion chamber, and maintaining a fluidized bed temperature in the combustion chamber in excess of 1400° F.

[0013] In a fourth separate aspect of the present invention, the process for reducing the particle size of the ash includes grinding the ash to reduce the particle size. The grinding may be performed to generate ash having a desired particle size, the particle size being indicative of the softness of the newly produced paper products. For example, towel and tissue products generated from ash having approximately 90% of its particles, by weight, at less than 40 micrometers have been found to be acceptably soft for many consumer uses. The reduction process may also include grading the ash to selectively remove unwanted large particles.

[0014] In a fifth separate aspect of the present invention, energy from the combustion process is captured for use elsewhere in the recycling and paper products manufacturing processes. This energy may be captured in the form of steam and used,

for example, to dry the sludge stream or as part of the process for producing new paper products.

[0015] In a sixth separate aspect of the present invention, any of the foregoing aspects may be employed in combination.

[0016] Accordingly, it is an object of the present invention to provide an improved method of recycling wastepaper. Other objects and advantages will appear hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] Fig. 1 illustrates a method of method of recycling wastepaper in accordance with a preferred embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0018] Turning to Fig. 1, the wastepaper stream is initially processed (101) to break down the wastepaper into its component parts and enable separation. This process includes several stages that are well known to those skilled in the art. The wastepaper stream initially undergoes a pulping stage, in which the wastepaper is subjected to mechanical agitation and chemical treatment, to begin separating the long fiber content from the fines, fillers, inks, etc. The contents of the wastepaper stream are suspended in solution following the pulping stage so that the stream may be passed through screens to remove coarse contaminants such as the staples, paperclips, and other large foreign objects.

[0019] After the screening stage, the wastepaper stream is moved to a washing stage. Chemicals are added to the wastepaper stream to lift ink and other particles from the long fibers. Most commercial de-inking washers that are available in the market, such as washers manufactured by Kadant Black Clawson of Ohio, have two modes of operation. In the first mode, the washer separates the long fiber, fines, and filler from the ink and other matter present in the wastepaper stream, thus yielding approximately

70% of the typical coated publication grade wastepaper for use in new paper products. In the second mode, the mode that is most relevant to the present invention, the washer separates the long fiber from the fines, filler, ink, and other matter present in the wastepaper stream, resulting in a long fiber stream and a sludge stream, respectively. This second mode of operation is referred to as fractionation.

[0020] The long fiber stream is useable in the production of new paper products without further processing. The sludge stream, however, must be further processed before it is useable. The further processing of the sludge stream includes drying (103), combustion (105), and particle size reduction (107). After the sludge stream is processed as described below, it is recombined (109) with the long fiber stream, and the combined streams may be as the base materials for the production of new paper products (111).

[0021] In the drying stage, excess water is drained from the sludge stream and the remaining wet sludge is pressed to remove additional water. After pressing, the sludge stream typically includes approximately 60% water or fluids and 40% solids from the wastepaper. The pressed sludge is then placed in a dryer to further remove water and fluids from the sludge stream. The dryer is a rotatable, elongated cylinder having an interior that includes a plurality of steam tubes, such as dryers manufactured by the Louisville Dryer Co. of Louisville, Kentucky. The pressed sludge is inserted into the interior of the cylinder and tumbled to further remove moisture through contact with the steam tubes. In this manner the sludge stream is exposed to temperatures of between approximately 150° F to 250° F. The pressed sludge is preferably dried until it composes approximately 40% water or fluids and 60% solids from the wastepaper stream. While more or less drying may be done, more drying would take additional time and may be unnecessary to complete the process as further described below, and less

drying may require additional time and/or energy in the combustion stage described below.

[0022] Following the drying stage, the dried sludge stream is inserted into a combustion chamber or oven for further processing. Optionally, the recycling process may be made more environmentally friendly by also collecting the gases emitted from the sludge stream in the dryer and feeding those gases into the oven as well. Many industry standard ovens that support fluidized beds, such as those available from Energy Products, Inc. (EPI) of Coeur d'Alene, Idaho, may be used for the combustion stage.

[0023] In the oven, the sludge is combusted at vapor temperatures of 1700° F or higher, the goals of which are at least threefold. First, the sludge should be almost entirely, if not completely, reduced to ash. Second, the organic compounds present in the sludge should be destroyed or reduced to carbon. Third, the combustion time and temperature of operation should be such that environmentally harmful chemicals, such as PCB, and other volatile organic chemicals, are reduced to a non-harmful form, while minimizing the formation of other undesirable compounds, such as carbon dioxide (CO). Maintenance of vapor temperatures as low as 1500° F, or even 1100° F, are generally sufficient to meet the first two goals, however, combustion at such lower temperatures might not sufficiently destroy environmentally harmful chemicals or minimize the formation of other compounds to the extent required by administrative agencies in states such as Wisconsin. As such; depending on the state in which the invention is practiced, the lower temperatures may be acceptable.

[0024] Prior to inserting the sludge into the oven, the oven is preheated to approximately 1750° F. Although no preheating is necessary, insufficient preheating of the oven may result in the emission of environmentally harmful chemicals that would otherwise be destroyed in an oven preheated to 1750° F or more. The oven is

preheated to above 1700° F because the temperature of the oven drop when the sludge is initially inserted into the oven.

[0025] Limestone is often used to form the fluidized bed within such ovens, however, the sludge renders the limestone unnecessary, as the bed may be formed by the sludge itself. When the sludge is placed the oven, combustion is at first maintained by an external fuel supply. After a short period of time, the length of which depends on the amount of sludge forming the bed, the organic material in the sludge, e.g., the fines, fuels combustion, eliminating the need to externally supply fuel. Autogenous, self-sustaining combustion of the sludge is thus achieved in this manner. The temperature of the sludge forming the fluidized bed is maintained at 1400° F or more. As with the vapor temperature, this fluidized bed temperature is set to meet state emission requirements. Otherwise, fluidized bed temperatures as low as 1200° F, or even 900° F, may be sufficient to fully combust the organic matter in the sludge stream and reduce the inorganic matter to ash.

[0026] The vapor temperature of 1700° F or more and fluidized bed temperature of 1400° F or more are maintained for at least a period of five consecutive minutes to substantially vaporize and destroy the environmentally harmful chemicals present in the sludge. More or less time may be appropriate depending upon the amount of sludge in the oven and the actual temperatures within the oven. This residence time at these temperatures is also sufficient to break down most, if not all, of the components of the sludge. For example, a filler of calcium carbonate would be reduced to calcium oxide, and the organic fines would be vaporized, leaving in the oven at most a base form of carbon as residue.

[0027] During the combustion process, certain parameters of the oven are controlled to minimize the production of additional environmentally harmful chemicals, such as NO_X and SO_X, as byproducts of the process. For example, many ovens enable

the control of oxygen and aqueous ammonia in the combustion chamber. A low oxygen environment in the combustion chamber, combined with injection of aqueous ammonia, allows selective catalytic reduction to prevent NO_X formation. In addition, fluidized bed temperatures of approximately 1400° F or more, in combination with the presence of calcium oxide from the breakdown of the fillers in the sludge, help control the formation of SO_X.

[0028] One important byproduct of the combustion stage is heat energy, which may be in the form of steam. Steam as a source of power is transportable within a facility for use in the production of new paper products or in a separate stage of the recycling process. For example, steam generated during combustion might be advantageously employed in the aforementioned sludge drying stage. By way of another example, the power from the combustion stage might be advantageously employed at any appropriate stage, such as the drying stage, in the production of new paper products.

[0029] The ash generated in the combustion stage is moved into the reduction stage, in which the overall particle size of the ash is reduced. Much of the ash is converted into minerals during combustion, and as is well known in the paper production art, some minerals may be combined with long fiber to produce paper products having a varying degrees of softness, from a fairly coarse product to softer products such as towels and tissues. The softness of the final product appears to be tied to the particle size of the mineral combined with the long fiber. Therefore, the size to which the ash particles are reduced is a function of the desired softness or coarseness in the final product. For towel and tissue products, an acceptable level of softness may be obtained by using ash having a particle size that is approximately 90%, by weight, under 40 micrometers. By way of further example, towel and tissue products

made from ash being largely composed of approximately 74 micrometer particles have been found to have a gritty feel.

[0030] Reducing the particle size is generally a multi-step process which includes grinding and grading the ash repeatedly to achieve the final desired properties. The grinding may be wet or dry. Wet grinding may be accomplished using grinders available from SWECO of Florence, Kentucky, which are commonly employed in the recycling process. The grading is carried out by passing the ground ash through a mesh or sieve to cull out the larger particles. These two steps are repeated as necessary to achieve ash having the desired particle size.

[0031] Following the reduction stage, the ground and graded ash is suspended in slurry having approximately 20% solids from the ash. Other concentrations of ash in slurry may be formed as appropriate. The solution is thereafter metered into the long fiber stream in a predetermined amount. As with the particle size of the ash, the concentration of the ash slurry and the amount of ash metered into the long fiber stream may vary depending upon the desired properties of the paper product to be produced. Such properties include, among others, softness, tensile strength, bulk, and color. Production of new paper products, including towel and tissue products, may proceed with the combined long fiber and ash stream by processes known to those skilled in the art for producing such products.

[0032] Thus, an improved method of producing paper products from recycled fiber is disclosed. While embodiments of this invention have been shown and described, it will be apparent to those skilled in the art that many more modifications are possible without departing from the inventive concepts herein. The invention, therefore, is not to be restricted except in the spirit of the following claims.